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Equilibrium and Transformation in the Standard Making Process

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Abstract
This article analyses the dynamics of the standard making process by explaining these dynamics in terms of the equilibrium in, and the transformation of powers, interests, knowledge, etc. of those involved. We consider two questions: ***1) how do transformations take place, and 2) what are the conditions for achieving equilibrium****. The analysis is based on arguments from economic and social theory.*
By equilibrium we denote a ***specific configuration*** *of interests, relations, environment settings, which are the result of a successful negotiation process. By transformation we denote the* ***transformation of interests and relations*** *between those involved and possible changes in the process environment. The transformation reflects the changes caused by the advance of the standardisation process. We contribute to theory by proposing a novel approach to the socio-technical perspective of the standardisation process. The work's contribution to practice a fresh view of technological development cycles for managers involved in standardisation initiatives.*

Keywords**:** *standard making, equilibrium, transformation, standardisation process*

1. Introduction

Technological standards play an important role in any high technology industry. In industries like telecommunications standard making has become one of the core strategic challenges. Nelson admits that *"quite often when a new technology comes into existence, there is very little scientific understanding relevant to it. However, the appearance of that new technology then induces scientific research to understand it, and lay the basis for its subsequent development"* (Nelson, 1994) (p.56). In earlier work we[1] have made an attempt to contribute to the newly developing theory of standard making by arguing that there are dynamics embedded in the standard making process (Fomin, 1999). The notions of equilibrium and transformation in the standard making process were introduced, and six iterative stages of the process were defined[2]. Here, we further extend this theoretical elaboration and use a case study analysis to validate the theory.

In this paper we are expanding on these notions of equilibrium and transformation to consider the following questions: how do transformations take place, and what are the conditions for achieving equilibrium in the standard making process. By *equilibrium* we denote a **specific configuration** of interests, relations, environment settings, etc., which are the result of a successful negotiation process (when agreement was reached) between those involved. In our cyclical process development model (See *Figure 1*) the equilibrium points are depicted as *"passages"* in points of time. Equilibrium is to be understood as a temporary state of a complex web of relations. It can be compared to that of catastrophe theory (Oliva, 1994). For example, in a committee led standardisation process the equilibrium point is that of reaching

[1] The author is a member of a research project STAMINA funded by Academy of Finland. For more information see http://www.jyu.fi/~wlad/stamina
[2] http://www-i4.informatik.rwth-aachen.de/~jakobs/siit99/Proceedings.html

an agreement on any issue, which allows the standardisation process to advance. By *transformation* we denote the **transformation of interests** between the involved actors, as well as the **transformation of relations** between the actors and, possible changes in the process environment. The transformation on a time continuum spans between the two points of equilibrium. The transformation reflects the changes caused by the advance of the standardisation process. The Oxford English Dictionary[3] defines ***"process"*** as (5.b.) *"the continuing interaction of human groups and institutions, esp. as observed and studied through its effect in social, political, cultural, etc., life, with the aim of finding underlying patterns of behaviour in the data available."* In our discussion of technology and technological innovation, we concentrate on standards, and in particular, cellular mobile telephony standards. In this paper we refer to a standard as an intangible artefact, a non-material good (not a steam engine, or videotape, etc.). An appropriate definition of a standard is provided by David*: "A 'standard' is to be understood ... as a set of technical specifications adhered to by a producer, either tacitly or as a result of a formal agreement"* (David, 1990). The focus of the paper is on *anticipatory* standards, i.e., standards that are created by formal organisations ahead of a product.

We construct our case by addressing the paths of the development of *anticipatory* complex technological standards, such as NMT[4] and GSM[5] standards for mobile cellular telephony. Arguments are developed from a case study of standardisation initiatives in the telecommunications industry, namely NMT and GSM mobile cellular systems. The proposed cyclical model of the standardisation process is based mostly on Social Shaping of Technology (SST) theory (Williams, 1996), and Actor Network theory (ANT) (Callon, 1992) in particular, and criticism of the mainstream literature on the economics of standards. It contributes to theory by proposing a novel approach, that is a socio-technical perspective of the standardisation process. It also has important practical implications for the management of standardisation initiatives, since it introduces a fresh view of technological development cycles.

2. Criticism of the economic literature

In earlier work we provided a detailed review of the inadequacy of economic theory to account for the standardisation processes in the Information Technology (IT) domain (Keil and Fomin, 2000). In this section I shall outline the main points of that criticism.

Cellular telephony is a good example of a complex, non-unified technology and its related interpretative flexibility (Lyytinen and Damsgaard, 1998). The meaning attributed to the cellular technology during development was not the same for all those involved. In both cases of NMT and GSM standardisation, operators aimed at long-time operation, profits were to be seen only in the long run (Lyytinen, Manninen, and Fomin, 1998; Meurling and Jeans, 1994). On the other hand, producers aimed at immediate profits and high volumes of production, whereas users were concerned more with the availability of service, its quality, high network coverage and affordability. In response to the above, regulatory bodies had to implement Pan-Nordic (NMT) and Pan-European (GSM) policies and resolve policy conflicts (Lyytinen et al., 1998; Manninen and Fomin, 1999; Toivola, 1992). When faced with diverse social forces

[3] (Simpson and Weiner, 1989)
[4] Nordic Mobile Telephone
[5] Global System for Mobile communications

the innovation process requires an alignment[6] of multiple interests in the social construction of the innovation's significance, the negotiation of the scope and content of standards, and the legitimisation of the acceptable uses of the innovation (Lyytinen and Damsgaard, 1998). Technology is not an artefact with predetermined features or preordained impact on the market[7]. Neither market, nor the technology under development are closed systems -- both are subject to the influence of socio-institutional forces in the environment, in which the technology is being developed and adopted. Diverse socio-institutional forces have a direct impact on the innovation process (Choh, 1999; Lyytinen and Damsgaard, 1998). For many years researchers and practitioners have argued that the classical economic perspective on market forces positing that a superior technology will be chosen by the market lacks an understanding of the influence of the socio-institutional environment upon the innovation (Choh, 1999; Pinch, 1988). By recognising the importance of the environment in which the technology develops, we expand economic reasoning by acknowledging the influence of governmental and regulative bodies, industrial consortia, the institutional and technical culture of the developers, and the adopters of the innovation.

Economic theory has studied why standards emerge, how technology adoption progresses, and what are the welfare implications of the emergence of standards. Attempts to model standardisation processes have often used game theoretic model set-ups. For instance, Farrell and Saloner (1988), compared standardisation processes with respect to market mechanisms and committees in a game theoretic framework. Game theoretic models of standardisation differ in their definition of the underlying structure of the game. What they share, is the assumption of purely rational actors. The effects of social relationships and the forces that these exert on the decisions of actors are ignored. A criticism however posits that actors often need to weigh up economic and social factors in their decision making: *"There also may be processes of coalition building that can nudge the outcome one way or another, which may have little to do with projections of long run economic efficiency..."* (Nelson, 1994) (p.52). Game theoretic models would seem to be better suited to identify possible dominant outcomes from standardisation processes, rather than the process of reaching any of the possible outcomes: *"One can not evaluate the comparative performance of the voluntary committee process for 'anticipatory' standards within this [game-theoretic] framework, since there is no market game to be played before products have been designed..."* (David, 1990) (p.37). Taken together the aforementioned arguments, economic theories are only to a very limited extent suitable to model the complex socio-economic processes that underline the standardisation of complex technological systems. *"The statement about the failure of formal theories to capture the developmental aspects of growth holds for both formal neoclassical and formal evolutionary growth theory"* (Nelson, 1994) (p.48).

Other literature has examined the evolutionary development of technology. In earlier work[8] we addressed the idea of the lineage of technology, reflecting on Levinthal's (1998) work. We looked at how the convergence of technologies takes place, bringing forth a new technology.

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[6] By **alignment of interests** we understand a (successful) process "*in which sets of relations between projects, interests, goals, and naturally occurring entities – objects which might otherwise be quite separate from one another – are proposed and brought into being*" (Callon and Law, 1989) (pp.58-59).

[7] See e.g., (Callon, 1992; Lyytinen and Damsgaard, 1998; Meurling and Jeans, 1994; Pinch, 1988; Star, 1991)

[8] *(Fomin and Lyytinen, 2000)*

Levinthal provided two distinctive criteria for the development of a technology within a new domain: a distinct basis of selection (market criteria) and an abundance of resources available for the technology's development. He regarded the lineage of technological development as reflecting that of evolutionary biology. Gould criticised this perspective, providing two other criteria: *"to understand the survival (and domination to this day) of drastically suboptimal QWERTY [standard for keyboard layout], we must recognise two other commonplaces of history, as applicable to life in geological time and as to technology over decades - contingency and incumbency"* (Gould, 1997) (p.72). I don't disagree with either of the authors. By recognising the role of ***contingency*** and ***incumbency*** we are however, moving away from Levinthal's purely economic reasoning. *"Contingent events often depend crucially upon choices from a distant past that seemed tiny and trivial at the time"* (Gould, 1997) (p.73). In support of our inclination towards contingency driven technological development, one can argue that one important character of a complex *internetworked* and *infrastructured* standard (as in any cellular mobile telephony) is the **unpredictable behaviour** associated with the standard. In other words, the **contingency** exists not only prior to standard implementation, but also during the standardisation process and after it's introduction. Ciborra and Hanseth described the building up of infrastructure in terms which hold well for the standards in our case studies (Ciborra and Hanseth, 1999). They argue that *"a large infrastructure... might also be a powerful actor influencing its own future life because of its extension and size as well as its form."* They call standards *self-reinforcing mechanisms* characterised by *network externalities* and *path dependency* and *"highly influenced by a small advantage gained in the early stages"* (Ciborra and Hanseth, 1999).

To summarise the economic literature's criticism and reaffirm our inclination towards a social construction of technology, I shall take another brick off the economic perspective's foundation in favour of social construction theory. The following two citations support the findings of David (1990), that: *"... the actions of multiple stakeholders and their limited scope, externalities and transaction costs, combined with the influence of non-liner development processes make the outcome of any [infrastructure, read 'standard'] implementation less predictable than the management and engineering literature would like us to believe"* (Ciborra and Hanseth, 1999). In line with these arguments are the findings of Nelson with respect to the evolution of technology: *"the processes involved here are not market processes, at least not of the standard variety, but involve the forming of collective bodies, decisions of voluntary organisations, government agencies, and political action"* (Nelson, 1994) (p. 55).

3. Case Methodology

We derive my theoretical arguments from two case studies of the standardisation processes. These case studies are used to elaborate the meanings of the equilibrium and transformation of standard setting and diffusion processes. Our methodology is motivated by both concern for processes and for theory building.

First, our concern is with highly complex processes that take several years to unfold. To capture the richness and complexity of these processes would seem virtually impossible in a cross-sectional design (Yin, 1994). The case method is far better suited to capture longitudinal phenomena. Second, our concern is with theory building, not theory testing. Rather than deriving hypotheses from a single existing body of theory, we are aiming at exploring how, through the interplay of different perspectives the richness and essential

characteristics of the phenomenon can be captured.

Several key challenges exist in case study research. One challenge is the generalisability of the results derived from a limited number of cases. The author believes the findings to be generalisable due to the proper selection of the cases. The given cases represent a good overview of different standardisation modes on a continuum ranging from market driven *de facto* standardisation (NMT) to committee driven *de jure* standardisation (GSM). Earlier works confirm that a proper process analysis allows the findings to be generalized. "*Prediction of patterned regularities over time is one of the goals of process theory research... Findings can be generalized to other settings, and predictions can be tested in later research*" (Markus and Robey, 1988) (pp. 592-593).

A second key challenge is to establish the reliability and validity of the data (Adams and Schvaneveldt, 1991). First, we use several sources of data. Interviews with managers in the standardisation processes were conducted (Lyytinen et al., 1998; Lyytinen, Manninen, and Fomin, 2000; Manninen et al., 2000; West, 1996a; West, 1996b). Interviewed managers were either key decision makers or standardisation specialists (See *Attachments, Table 1*). In both the cases of NMT and GSM cellular telephone systems, former chairpersons of the standardisation committees were interviewed. Furthermore, written documents, memos and public announcements were used to corroborate the findings from the interviews wherever possible. NMT and GSM projects' documentation was acquired from public archives in Uppsala, Sweden. Collected documents included minutes, letters, and project correspondence. In total, over 7´900 pages of documentation were scanned and OCR[9]-processed, making a content analysis possible. Using several sources of information allows the researcher to triangulate data and improve the reliability and validity of the findings derived from the case material (Yin, 1994).

The two cases differ significantly in the complexity of the technology involved, the number of industries, individuals and firms involved, and the time length of the standardisation process. Furthermore, the two processes cover two decades, i.e. the 70s, and 80s. During that span of time, organisational structures have changed significantly. The choice of cases allows us to generate theory that is better generalisable than a theory derived from a single case or too similar cases. The approach presented in the paper shows that standardisation practices can be analysed successfully regardless of the dominant contemporary organisational structures.

4. Case Overviews

The case of the NMT standard is an excellent example of a successful standard-making process (Fomin and Lyytinen, 2000). There are several reasons why it is an interesting case for analysis. First, it was created at the time when there was a market demand for this kind of technology, but the needed technology was not yet available (Toivola, 1992). Second, it was developed almost at the same time as another major cellular telephony standard, namely AMPS[10] in the US, but witnessed much broader acceptance and success (Fomin and Lyytinen, 2000; West, 2000). The developers of the NMT system built stakes in the rapid advance of the radio and micro-electronic technology and designed the system "for the future". They ignored the fear of facing a high level of uncertainty due to their ability to

[9] OCR – Optical Character Recognition
[10] Advanced Mobile Phone System

anticipate in 1969 that what national PTTs had was "*really a technology for the 60s, and that wouldn't do it for the 1970s*" (Lyytinen et al., 1998). This move necessitated the PTTs to create close relationships with otherwise external producers of telephone, radio, and micro-electronics equipment. We believe there were important social and cultural implications in the standard settings, which facilitated the standard creation process and paved the way for the standard to be delivered to the market. One can see how the socio-technical environment, in which a given technology develops, can either be a facilitator or a hindrance for the technology's development, e.g., the North American AMPS system can be compared to the Nordic NMT. The AMPS system, developed by ATandT and ready for implementation already in 1962, had spent more than a decade "on a shelf" (Bekkers and Smits, 1998; Mehrotra, 1994; Paetsch, 1993). In contrast, after the development and immediate introduction of the NMT system, European countries found the growth of the system exceeded early estimations (e.g. by 300% in Norway).

The second case presented, the GSM cellular telephony system, is interesting because of the intricate paths of political interests and ambitious aims of the European PTTs in the system's development process. Even before the NMT-450 was introduced, European PTTs were involved in negotiations on the creation of a pan-European system. At the end of the 1970s' CEPT reserved a band of 900 MHz for land mobile telephones. Already in 1980 a shared opinion existed among European PTTs that every European country would benefit from the introduction of a pan-European system (Bekkers and Smits, 1998; Meurling and Jeans, 1994; Toivola, 1992). As a result, in 1980, there was a call from the French PTT to other European PTTs for developing a common pan-European automatic cellular system. Nordic Countries, committed to perseverance and thereby ensuring their leading position in the area of mobile telephony, reacted to the call by establishing a new work group for studying the possibilities of developing the next generation NMT system (Toivola, 1992).

Non-official discussions at a Paris meeting in 1980 revealed that CEPT would be too cumbersome and slow to lead the standardisation work of a common European mobile system[11] (Manninen, 1999). It resulted in establishing a Groupe Spéciale Mobile (GSM) -- a body subordinated to CEPT/CCH. The aim of GSM was to harmonise technical and operative specifications for a public mobile system on the 900MHz frequency band (Toivola, 1992). The creation of GSM would end the traditional European fragmentation and incompatibility in the mobile field (Mouly and Pautet, 1992), where, due to the different interests of national operators, the utilisation of incompatible systems flourished[12].

One important step towards the normalisation and strengthening of an European cellular market was the signing of the Memorandum of Understanding (MoU) by 13 network operators from 12 European countries in 1987[13]. It opened doors for manufacturers to converse with the standard making bodies, which later proved to be an important factor in establishing European dominance of the world cellular market (Bekkers and Smits, 1998). In

[11] CEPT was the only organisation available at that time with its sub-body CCH, and was responsible for harmonisation tasks.

[12] In the mid 80's, the Nordic Countries and Switzerland had started operation of the NMT-900 system (a 1+ generation of the NMT-450). Most other European countries had either adopted an European version of the North American AMPS system (e.g. U.K., Ireland, Spain), or developed their own proprietary systems (e.g. Germany, France) (Bekkers and Smits, 1998).

[13] By the end of 1994, the number of signatories of the GSM MoU was 102, including operators, regulatory bodies, and manufacturers.

the case of GSM the way to success was neither easy nor straightforward. It was a heavily political and technologically challenging process. The difficulties involved included high risks, diverse interests, the inadequacy of the digital technology in hand, competing technical specifications, controversial market demands and tensions between openness and intellectual property rights (IPRs)[14] -- all these constraints seemed to be typical of large scale standardisation processes.

5. Equilibrium and transformation in the standard making process

"The development of an anticipatory standard can be understood as an exercise in collective engineering research and consensus-based product design" (David, 1990) (p.34). In order to understand how a complex standard making process evolves, from its inception to introduction, we propose a model, which we believe grasps the very nature of a socio-technical standard making process. The model is presented in *Attachments, Figure 1,* and has got 4 iterative passages. We believe that the strength of this model, compared to those proposed by either the economic or evolutionary development literature, is of being applicable to both a micro- and macro analysis of a process, and accounting for both the inter-organisational relations of actors and the changes in the external environment, in which the new technology develops. In the subsequent sections I shall briefly introduce the passages of the model.

Passage 1. Equilibrium

A state of affairs prior to the initiation of standardisation work can be considered as equilibrium. In other words, a "pre-process" or "no-process" situation has a certain configuration of the environment in which the new technology is to be developed. We shall call this state **equilibrium** since there is no explicit move towards a new technology. According to Levinthal (1998), there should be a shift in the application domain for existing technology to have a "**speciation event**", that is, when a novel technology is brought forth. It can be also that the market-pull demands that it's need for a new technology is satisfied. When a **transformation** of the environment takes place and existing socio-technical networks are re-structured or newly established to give impetus to the development of a novel technology, a shift towards **imbalance** occurs. The existence and uses of mobile telephony systems available before the initiation of NMT and GSM standardisation work we shall call the initial equilibrium.

Passage 2. Imbalance

When the NMT working group was set up at the Nordic Radioconference in 1969, the primary issue for the working group was to make mobile telephone systems in the Nordic countries fully compatible (Toivola, 1992). By creating a compatible system, national PTTs would provide a sufficiently large market to get manufacturers interested, and to provide a better service to subscribers. Also, in the case of GSM, already in 1980 a shared opinion existed among European PTTs, that each European country would benefit from the introduction of a pan-European system. As a result, there was a call from the French PTT to European PTTs to develop a common pan-European automatic cellular system. Despite the willingness of actors to engage into a standard making process, divergent interests may become a hindrance to the process development:

[14] See more on IPR issues in GSM in (Bekkers and Liotard, 1999)

In February 1987 we had a meeting which ended in disagreement. Germans and French wanted a wide-band system, and the rest of the Europe wanted a narrow-band system. The technical people in GSM agreed we should have this narrow-band system. But political people in Paris and Bonn dictated the opinions of PTTs…

The example above also points to the absence of equilibrium between the macro and micro organisational layers (Fomin, 1999; Fomin and Lyytinen, 2000).

…These nations' representatives were instructed to vote for the wide-band system. Of course, the ministers who took the decisions were not present. And they had a lot of political reasons. They've spent a lot of money on the experimental systems and they wanted something to get for their money (Manninen and Fomin, 1999).

The example above and the two case studies included, show how an arena for the standardisation process is being set up, and how the involved actors are about to engage in creating a **shared meaning**, which is the next passage in our model.

Passage 3. Shared meaning

Standards are boundary objects that help create meaningful conversations between otherwise unconnected actors. The concept of the boundary object was first introduced by scholars of social science and ethnography (Star and Griesemer, 1989) and later witnessed broad acceptance in the field of social studies of technology. Star defines the boundary object as follows: "***boundary objects*** *are objects which are both plastic enough to adapt to local needs and constraints of the several parties employing them, yet robust enough to maintain a common identity across sites. They are weakly structured in common use, and become strongly structured in individual-site use*" (Star, 1992). Through working on standards, actors can create new common understandings. During the NMT and GSM system development, the notion of boundary object can be helpful in understanding the dynamics of the standardisation process (Fomin and Lyytinen, 2000).

At the time when the first generation cellular mobile systems were created in Europe, due to technical, economic, and political reasons the European cellular market became very fragmented. Seeing a need for the development of second generation[15] cellular systems to satisfy the growing demand for higher capacities and better services, many countries initiated research aimed at the creation of a new cellular system. A pan-European standard would serve as a boundary object linking the otherwise fragmented markets into a single pan-European market. The GSM standard would help align the interests of manufacturers seeking a large market, the interests of national operators seeking to increase traffic and the number of subscribers, and the interests of cellular network subscribers seeking a trouble-free network in Europe with their terminals. In the cases of GSM and especially NMT, manufacturers were not able to foresee the scale of the production, and the developers of the NMT standard had to enrol industry in the construction of the needed technological solutions:

[15] The 1st generation cellular systems, e.g. NMT and AMPS, used analogous voice transmission. The 2nd generation cellular systems, e.g. GSM and D-AMPS, are using digital voice transmission and are capable of transmitting data. The principal difference of the 3rd generation cellular mobile telephony, also known as Universal Mobile Telephone System (UMTS) and Future Public Land Mobile Telephone System (FPLMTS), is that the voice transmission function is not the major function anymore. Transmission of data (multimedia in particular) at high rates is the main function, and the voice is seen as one of instances of the data transmission.

With manufacturers we [PTTs/ mobile operators to be] had different objectives. They've got shareholders, and if the manufacturer does not make a profit, it will be decapitated by shareholders. On the other hand a mobile operator must think of a lot of other aspects: he has to make it as cheap and attractive as possible for the suppliers or customers, but she can also think on a long-term basis (Lyytinen et al., 1998).

The need to create shared meaning and understanding is often so strong that it blurs the traditional boundaries of competition. In this section the analysis provides insight into why economic reasoning is not sufficient in the analysis of standard making. The meaning of a standard as a boundary object helps to understand how different parties with conflicting interests might come together. The NMT-450 and consequent standards, including the GSM emerged to a large extent from the work of small engineering-oriented work teams operating without formal organisation or diplomatic sanctions (Fomin and Lyytinen, 2000; Knuuttila, 1997). The spirit of Nordic Co-operation created a fertile soil for establishing communication channels between and within industries in the Nordic region. In contrast to the classic economic theory positing that innovation is driven by competition and market selection, the case of the NMT standard shows that the main impetus for innovation can come from co-operative practice as well:

[The development of the NMT] was driven by enthusiasm. And we did not look at the commercial side. Well, we did look, but it was not about the competition. We were cooperating, no fights, we had a support from the top management -- it was driven by a common goal. And we saw that the only way to get this all to operation was by working together -- we could not do it separately. [The project was] too big and the suppliers would not support us (Lyytinen et al., 1998).

Aside from being tied to structures and it's dependence on joint sense making, the standardisation process can also be conceived of as a negotiation process. Only through a process of **negotiation** and compromise is it possible to create a standard that can be diffused successfully. The negotiated need for a common standard makes it possible to bridge different visions and perceptions, and thus acts as a mediator between the needs of the involved parties.

Passage 4. Translation

A creation of a standard can be either market or technology driven. In any case the development of the standard begins from establishing the initial network of interested parties. It is a process of establishing communication channels and compromising one's interests. Negotiation and alignment of interests must take place if the process is to advance. The alignment of interests is the result of a successful translation of "*the images and concerns of one world into that of another*" (Star, 1991) (p.32). We see the negotiation process being rather politics than economics or technological imperative. A notion of a standard as a boundary object is useful in understanding this process. As there was no acceptable technology at hand, neither at the initiation of the NMT, nor the GSM standard, standard makers had to align their interests with manufacturers in order to solicit their support. The standard developers could not afford substantial RandD work in all technological domains. Instead, they involved industry by promising a substantial market, if the specifications could be met. At the time when the European GSM standard was developing, the world's manufacturers had already learned of the success of the cellular business. They were willing to be in. Establishing the ETSI and later the Memorandum of Understanding (GSM MoU)

gave manufacturers a possibility to influence the standard-making process. In the case of the NMT standard, manufacturers were not able to foresee the scale of the production, and the developers had to enrol the support of industry in order to obtain the needed technological solutions. The citation below shows how it was done:

We sent specifications to almost 200 addresses all over the world... Our philosophy was always to communicate with industry, get their feedback, but we made the decisions... Later we sent specifications also to component manufacturers, because if we had sent specifications only to mobile manufacturers, they would have thought of it in a different way and made the solutions in different ways (Lyytinen et al., 1998).

The example above shows how actors from an external environment can be enrolled into the process. As an abundance of resources needed for the development of technology became available as the manufacturers became involved, an equilibrium of relations was established, reaching out to the former external environment. A result of successful negotiation is a positive decision, an agreement, a "licence" to proceed with the standardisation work. Thus, we finish the first cycle of the iterative model, after going through several temporary states of equilibrium and transformation of powers, interests, relations, etc., and return to a state of balance (or equilibrium[16]). The first leap is over, how many are left to go?

6. Conclusion

In the empirical part of this paper we examined the standard making processes, which have spanned for several decades beginning from the late 1960s. We were looking at the different forces shaping the decision making process, at the enrolment of actors, at the sense making process, and, finally, how the interests of different parties have been aligned during the negotiation process either around a boundary object, a standard, or without it. The approach we presented encompasses arguments from economic and social theory. This approach allows us to analyse the whole standardisation process, from the inception of an idea to the implementation of the standard in the market, whereas most of the previous research has looked at these processes in separation (Farrell and Saloner, 1988; Rogers, 1995).

We develop the notions of equilibrium and transformation in the standard making process. In so doing we borrow notions from catastrophe theory (Oliva, 1994). Similar to models of catastrophe theory which examine incremental and radical changes in firm behaviour and account for the **interactions between short-run equilibria and long-run dynamic processes,** we propose an iterative model of **equilibrium and transformation** in the standard making process.

The analysis of the two cases reveals several interesting aspects of how standards are created. We emphasised a continuous negotiation process, showing how communications channels between the actors in the core network and beyond its boundary need to be established in order to provide an efficient standardisation process. The cases show how a core network of interested actors is formed, how sense making takes places, and how interests are negotiated between the involved parties. In some cases the standard itself serves as a boundary object, around which agreements are made and interests aligned. In other cases, agreements must be reached across diverging interests. In contrast to many existing models, which take either a

[16] Also referred to as **stabilisation** or **closure** in ANT.

macro- or micro- perspective on organisational processes, our proposed model can be used for both **macro- and micro-** analysis. By recognising both levels of organisational analysis we account for contingency in the path of technological development.

The arguments in this paper show how the techno-economic structures appropriate for different stages of the innovation process need to be transformed over time. Standardisation processes go through transformations and the management of these transformations is an important factor contributing to success or failure. We considered two questions: **1) how do transformations take place, and 2) what are the conditions for achieving equilibrium**. The analysis is based on arguments from economic and social theory.

Outcomes of a process are predictable from the *knowledge of process*, not from the level of predictor variables (Robey, 1995). It suggests that in order to anticipate the future development of processes, one must have knowledge of the process, i.e. it's actors and the relations between the actors, and knowledge of how the relations transform over time. In other words, to know how these objectives of involved *actors "are modified and how participants translate goals into actual designs"* (David, 1990) (p.36). We believe this work makes a step towards a theory of standard making and understanding this complex phenomenon.

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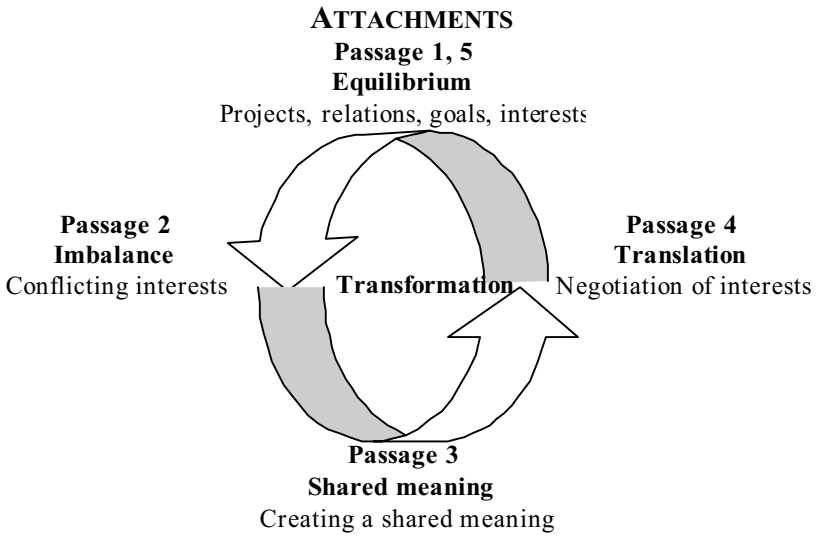

Figure 1. "Equilibrium and Transformation in Standard Making Process"

Table 1. "Conducted interviews"

Name	Position	Company	Country
Pekka Vannamo	Director General	Finnish PT	Finland
Olavi Koistinen	Director	Telecom Finland Oy	Finland
Matti Makkonen	VP	Telecom Finland Oy	Finland
Lauri Melamies	Sr.VP, mobile switching, cellular systems	Nokia Telecommunications	Finland
Lauri Kivinen	VP, communications	Nokia Mobile Phones	Finland
Tapani Pökkä	Business Development Director	Telecom Finland Oy	Finland
Keijo Toivola		ex-Finnish PT	Finland
Thomas Haug	ex-chairman GSM	ex-Televerket	Sweden
Eric Berthels	VP, marketing and sales	Ericsson Radio Systems AB	Sweden
Per Björndahl	Manager, systems management GSM/DCS/PCS, Telecom Standardization and Regulation	Ericsson Radio Systems AB	Sweden
Osten Mäkitalo		Telia AB	Sweden
Hans Myhre	ex-chairman NMT	Telenor	Norway
Per Velde	Manager, product development	Telenor	Norway
Ole Lauridsen	Corporate director, RandD	TeleDanmark	Denmark